

P 96/989



U. S. DEPARTMENT OF COMMERCE

**NATIONAL TELECOMMUNICATIONS AND
INFORMATION ADMINISTRATION**

PUBLICATIONS ABSTRACTS

Fiscal Year 1989

NTIA Publications Office
325 Broadway
Boulder, Colorado 80303
(303) 497-3572

C 60.13:

**READER
FICHE**

best copy available

PREFACE

This document contains a listing of fiscal year 1989 publications that have been authored by members of the staff of the National Telecommunications and Information Administration (NTIA). These publications represent one form of reporting the results of research and engineering studies carried out as part of NTIA's mission.

The abstracts contained in this listing represent, in abbreviated form, the final product of the available NTIA research for fiscal year 1989.

A limited number of journal reprints are generally available and may be requested from the author. The journals are usually available in technical libraries. NTIA Reports may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Publications showing a Superintendent of Documents (SupDocs) stock number may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

CONTENTS

	Page
EXTERNAL PUBLICATIONS	1
CONFERENCE PROCEEDINGS	3
NTIA REPORTS	9
SPECIAL PUBLICATIONS	15

External Publications

Liebe, H. J. (1989), MPM--An atmospheric millimeter-wave propagation model, *International Journal of Infrared and Millimeter Waves*, Vol. 10, No. 6, pp. 631-650

A broadband model for complex refractivity is presented to predict propagation effects of loss and delay for the neutral atmosphere at frequencies up to 1000 GHz. Contributions from dry air, water vapor, suspended water droplets (haze, fog, cloud) and rain are addressed. For clear air, the local line base (44 O₂ plus 30 H₂O lines) is complemented by an empirical water-vapor continuum. Input variables are barometric pressure, temperature, relative humidity, suspended water droplet concentration, and rainfall rate.

Manabe, T., R. O. DeBolt, and H. J. Liebe (1989), Moist-air attenuation at 96 GHz over a 21 km line-of-sight path, *IEEE Trans. on Antennas and Propagation*, Vol. 37, No. 2, February, pp. 262-266

A propagation experiment at 96 GHz over a line-of-sight path provided data on attenuation characteristics of atmospheric water vapor. Two consecutive time periods (3 days in May and 1 and 1/2 days in August, 1986) with a total of about 100 h of data on signal level and meteorological conditions were analyzed with respect to absolute humidity (3-21 g/m³) and temperature (4-32 °C) variations. Experimental details, the data analysis, and a comparison with model predictions are discussed. The field experiment tends to uphold the validity of the millimeter-wave propagation model MPM.

Rush, C., M. Fox, D. Bilitza, K. Davies, L. McNamara, F. Stewart, and M. PoKempner (1989), Ionospheric mapping: an update of foF2 coefficients, *Telecommun. Journal*, Vol. 56, No. III, pp. 179-182

A new set of coefficients to numerically map the global variation of foF2 has been developed by a Working Group under the auspices of the International Union of Radio Science. This article describes how these new maps were obtained, and presents the results of tests to determine the extent to which they are an improvement above the current International Radio Consultative Committee (CCIR) maps.

Conference Proceedings

Allen, K. C. (1989), Pattern recognition techniques applied to the NASA-ACTS order-wire problem, AGARD Conf. Proceedings, No. 453, Operational Decision Aids for Exploiting or Mitigating Electromagnetic Propagation Effects, San Diego, CA, May 15-19, pp. 50-1 - 50-11

The National Aeronautics and Space Administration (NASA) is planning to launch an Advanced Communication Technology Satellite (ACTS). This satellite will use several methods to adaptively mitigate the effects of fading due to rain in its 20- and 30-GHz links. A decision algorithm is needed to control the implementation of these mitigating techniques. The use of a learning pattern recognition algorithm as the solution to this problem is explored here. The algorithm is applied to data simulating fading on a slant path through the atmosphere at 20 and 28.8 GHz. The data were scaled from data measured on a 1-km path at 28.8 GHz in Hilo, Hawaii. The sole cause of fading in the data was attenuation due to rainfall on the path. The results indicate, at least for the test data, that the use of the most recently measured value of the received signal level (RSL) is adequate for predicting the future RSL and can be used to decide when the mitigating techniques should be used. More complicated algorithms based on linear combinations of previous RSL samples do not perform significantly better than the simple previous value approach.

Bloomfield, R. S. (1988), Architectural considerations for accessing the post-1995 CONUS DCS/DSN: Target MILDEP local information transfer networks, IEEE 1988 Military Communications Conference (MILCOM '88), San Diego, CA, October 23-26, pp. 16.7.1 - 16.7.8

Proposed architectures for the post-1995 CONUS DCS/DSN represent a radical departure from the AUTOVON-based networks extant. As a critical component of the DCS/DSN, the access node configurations provide the interface between the long-haul and local MILDEP information transfer systems--with significant implications for service provision, system performance, cost, and architectural flexibility. After establishing the need for employing a functional architecture design paradigm, this paper explicitly considers target MILDEP local information transfer architectures as an important input for the design of post-1995 CONUS DCS/DSN access architectures.

Bloomfield, R. S., and K. P. Spies (1989), User-oriented performance evaluation of data communication services: Measurement design, IEEE Communications Society, IEEE Int. Conf. on Commun., Boston, MA, June 11-14, pp. 3.4.1 - 3.4.7

The Institute for Telecommunication Sciences (ITS) has conducted extensive measurements of data communication networks to assist the development of American National Standards and CCITT Recommendations for user-oriented performance evaluation of data communication services. This paper, the first of two companion papers, discusses the experimental design used by ITS to measure the user information transfer performance parameters specified in American National Standard (ANS) X3.102 on several U.S. public data networks. The experimental design was developed in accordance with the data communication performance measurement procedures specified in a related American National Standard, X3.141. Differences between the interface boundaries and events instrumented in these measurements and those specified in the CCITT X.130-series Recommendations are discussed. The companion paper reports the measurement results for a selected ANS X3.102 user information transfer performance parameter, Block Transfer Time.

Bloomfield, R. S., and K. P. Spies (1989), User-oriented performance evaluation of data communication services: Measurement results, IEEE Communications Society, IEEE Int. Conf. on Commun., Boston, MA, June 11-14, pp. 3.5.1 - 3.5.7

The Institute for Telecommunication Sciences (ITS) has conducted extensive measurements of data communication networks to assist the development of American National Standards and CCITT Recommendations for user-oriented performance evaluation of data communication services. This paper, the second of two companion papers, reports the results of ITS measurements of a particular data communication performance parameter, Block Transfer Time, on several public data networks. The measurements were conducted in accordance with the general requirements set out in American National Standards X3.102 and X3.141 and the specific experiment design described in the companion paper. Issues associated with the proper interpretation of end-to-end data communication performance values are identified and discussed.

Hubbard, R. W., and T. J. Riley (1989), Summary of propagation conditions and digital radio performance across the English Channel, IEEE Communications Society, IEEE Int. Conf. on Commun., Boston, MA, June 11-14, pp. 24.4.1 - 24.4.7

The transmission of digital information in microwave line-of-sight circuits can be easily degraded by multipath effects, particularly in long, over-water paths such as the English Channel. This paper presents the results of a test program designed to investigate the propagation conditions, the multipath parameters, and the performance of a new digital radio over this link.

The authors show that the performance of the radio is improved by adaptive equalization techniques used in its design. However, the performance was below expectations at times, and these specific problems are treated. The authors conclude that a dynamic aspect, namely, the rate of change of the multipath delay, is one cause for the unexpected degradation.

Jennings, R. D. (1989), Structured approach to system-independent test methodology, Int. Workshop Proceedings, Naval Postgraduate School, Monterey, CA, June 27-29, pp. 37-38

A structured approach to establishing uniform methods for specifying, assessing, and comparing the performance of various types of systems is presented. The approach involves the identification of input and output interfaces for the system, the definition of appropriate system functions, the identification of possible performance outcomes, and the definition of parameters to quantify these outcomes. These broadly applicable concepts are presented and two distinctly different applications are discussed.

Kubicheck, R. F., E. A. Quincy, and K. L. Kiser (1989), Speech quality assessment using expert pattern recognition techniques, Proc. IEEE Pacific Rim Conf. on Communications, Computers, and Signal Processing, Victoria, BC, Canada, June 1-2, pp. 208-211

Automatic assessment of voice transmission quality is increasingly important to users and providers of communication services and products. Human listener panels currently provide subjective voice quality information. However, this approach can be slow, expensive, and unreliable. An objective method for assessing quality based on statistical pattern recognition and expert system techniques is described here.

Quincy, E. A., and M. A. Ralston (1989), CAD and video teleconferencing network development, University Programs in Computer-Aided Engineering, Design, and Manufacturing, ASCE 7th Annual Conf., Laramie, WY, July 23-26, pp. 319-327

The Institute for Telecommunication Sciences is developing a prototype network to demonstrate the integration of a variety of services and methods for fulfilling Navy shipbuilding requirements. The primary objective is to integrate computer aided design, interactive high-resolution graphics teleconferencing, and video teleconferencing over the same networks. This paper describes proposed architectures at the local area, metropolitan area, and wide area network levels.

Quincy, E. A., D. J. Tomich, and R. F. Kubichek (1988), Expert pattern recognition method for technology-independent classification of video transmission quality, IEEE Communications Society, IEEE Global Telecommun. Conf., Hollywood, FL, November 28-December 1, pp. 40.2.1 - 40.2.5

This paper proposes a new method for objectively determining video transmission quality that is user-oriented and independent of coding/decoding and transmission technologies. The technique employs an expert pattern recognition system that operates on received-image measurements with unknown transmission impairments. The system provides quality classification on a minimum probability of error basis relative to subjective classification. The expert system employs statistical pattern recognition rules to perform low-level processing and an initial classification. Additional knowledge about subjective classification, visual perception, user requirements, and application bias are applied by the expert system to obtain a refined classification of image quality.

Seitz, N. B. (1989), Performance standards for packet-switched services, IEEE Communications Society, IEEE Int. Conf. on Commun., Boston, MA, June 11-14, pp. 3.1.1 - 3.1.8

Four new Recommendations on the performance of international packet-switched services were developed in CCITT Study Group VII during the 1985-1988 study period. Recommendation X.134 defines apportionment boundaries and packet layer reference events that provide a basis for performance description. The boundaries are physical interfaces at which CCITT Recommendation X.25 or X.75 procedures are used, and the events are corresponding interface state transitions. Recommendations X.135, X.136, and X.137 define

specific packet-switched service performance parameters and associated values. The parameters are measures of packet-switched service speed, accuracy, dependability, and availability applicable to end-to-end virtual connections and their component sections. The values are worst-case performance limits for the national and international portions of an international virtual connection. It is anticipated that these performance parameters and values will be widely used in the planning and operation of packet-switched services supporting international data communications. The approach used in developing the packet-switched service parameters has been adapted for use in developing performance parameters for Integrated Services Digital Networks (ISDNs).

Tomich, D. J., E. A. Quincy, and D. Parsavand (1989), Expert pattern recognition assessment of image quality, IEEE Acoustics Speech and Signal Processing Society, IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, Glasgow, Scotland, May 23-26, pp. 1799-1802

This paper proposes a new method for objectively determining video transmission quality that is user-oriented and independent of coding/decoding and transmission technologies. The technique employs an expert pattern recognition system that operates on features of a received image with unknown transmission impairments. An example of a candidate feature is provided. The system provides quality classification on a minimum probability-of-error basis relative to subjective classification. The expert system employs statistical pattern recognition to perform low-level processing and an initial classification. Additional knowledge about subjective classification, visual perception, user requirements, and application bias can be applied by the expert system to refine the classification.

Vogler, L., J. Hoffmeyer, J. Lemmon, and M. Nesenbergs (1988), Progress and remaining issues in the development of a wideband HF channel model and simulator, AGARD Conf. Proceedings, No. 442, Paris, France, October 17, pp. 6-1 to 6-19

Although high frequency (HF) communication systems have been used for many decades, these systems are currently the subject of renewed interest, particularly in assessing the capabilities of the HF channel with regard to wideband (of the order of 12-1000 kHz) signals. This interest has generated a need for wideband HF channel propagation measurements and the development of wideband channel models and simulators.

This paper provides a brief review of recent work in wideband HF, discusses some limitations of existing HF channel models,

describes ongoing work at the Institute for Telecommunication Sciences in the development of a validated wideband HF channel model, and concludes with a discussion of key technical issues remaining in the development of this model.

Wortendyke, D. R., M. H. Morris, and D. J. Atkinson (1989),
Performance testing of wide area networks, University
Programs in Computer-Aided Engineering, Design, and
Manufacturing, ASCE 7th Annual Conf., Laramie, WY,
July 23-26, pp. 311-318

Widespread use of data communications between campuses in geographically dispersed locations has produced a need for knowledge of telecommunication system performance. Two popular telecommunication methods for data exchange are packet networks and the newer high-speed, dial-up modems, both of which operate at 9600-19200 bps. While the cost trade-off between the two methods may be straightforward to compute, the performance trade-off is far more subtle. Use of two ANSI standards introduced in this decade, X3.102 and X3.141, help the user evaluate the more subtle differences. The Institute for Telecommunication Sciences (ITS) has played a lead role in the introduction and development of these standards, which define data communication user-oriented performance parameters and measurement methods for performance evaluation, respectively. ITS has developed a software measurement system to support these standards. This system is being used to evaluate data communication system performance over wide area networks. After a short test of a few minutes, a preliminary characterization of the system parameters may be computed. Of the 17 primary parameters defined by the standard, this characterization includes nine that relate to bit and block transfer characteristics. A second test with multiple accesses and disconnections would provide information about the remaining eight parameters that relate to access and disengagement. Sample data taken between the University of Wyoming and ITS in Boulder, CO, are presented.

NTIA Reports

Cohen, D., W. Grant, and F. Steele (1989), Meteor burst system communications compatibility, NTIA Report 89-241, March, 112 pp. (NTIS Order No. PB 89-191167/AS)

The technical and operating characteristics of meteor burst systems of importance for spectrum management applications are identified. A technical assessment is included that identifies the most appropriate frequency subbands within the VHF spectrum to support meteor burst systems. The electromagnetic compatibility of meteor burst systems with other equipments in the VHF spectrum is determined using computerized analysis methods for both ionospheric and ground-wave propagation modes. It is shown that meteor burst equipments can cause and are susceptible to ground-wave interference from other VHF equipments. The report includes tables of geographical distance separations between meteor burst and other VHF equipments that satisfy interference threshold criteria.

Key Words: compatibility; interference; meteor burst; spectrum management

DeMinco, N. (1989), Automated steerable nulling antenna processor (SNAP) model, NTIA Report 89-245, July, 26 pp. (NTIS Order No. PB 89-231740/AS)

This report describes an adaptive antenna computer model that simulates the behavior of a steerable nulling antenna processor (SNAP) in a jamming or interference environment. The model predicts the signal-to-(interference-plus-noise) ratio as a function of antenna parameters and interference environment. The model can be used to demonstrate the application of antennas with the SNAP for obtaining increased spectrum utilization or improved performance in an interference or jamming environment.

Key words: adaptive antennas; interference nulling; steerable nulling antenna processor

Farrow, J. E., and S. L. Rothschild (1989), User-friendly software for the design of digital line-of-sight radio links, NTIA Report 89-246, August, 66 pp. (NTIS Order No. PB 90-118472/AS)

This report presents a description of and operating instructions for digital line-of-sight programs. These programs, which run on a desk-top computer, automate the calculations involved in design of line-of-sight microwave radio relay paths. The programs manipulate information about Earth geometry, terrain profiles, ray paths, median basic transmission loss, variability of loss, equipment effects, and path performance. The computer hardware and software configurations are designed to be convenient to operate and to give the design engineer immediate access to calculated results corresponding to changes in design parameters. The programs are intended to be used interactively by persons having no experience in programming. The algorithms may be applied over a wide range of path parameters. The frequency range is from 1 GHz to 10 GHz; the path length may be up to 200 km; and the path must have adequate terrain clearance. The results of the calculations are given in terms of the requirements of MIL-STD-188-323.

Key words: computer software; digital radio; microwave radio; MIL-STD-188-323 requirements; radio path performance; radio relay

Frazier, W. E. (1989), Handbook of radio wave propagation loss, part II: (100-20,000 MHz), NTIA Report 89-242, April, 116 pp. (NTIS Order No. PB 89-195473/AS)

This handbook is intended to provide estimates of radio wave propagation loss between transmitting and receiving antennas of various heights and transmission frequencies above the assumed smooth-earth surface calculated using the NLAMBDA computer model. For many cases involving electromagnetic compatibility analysis, the curves of predicted transmission losses in this report may be used to estimate the transmission losses of the desired and undesired signals. These estimated loss values are given in dB as BASIC MEDIAN TRANSMISSION LOSS for antennas with effective heights up to 5000 m operating in the 100 to 20,000 MHz frequency range, over land or sea, at great circle Earth surface distances up to 1000 km. This handbook is an expanded version of NTIA Report 84-165, Handbook of Radio Wave Propagation Loss (100-1000 MHz), and includes curves for the additional frequencies of 500 MHz, 2000 MHz, 5000 MHz, 7000 MHz, and 20,000 MHz.

Key words: basic median transmission loss; electromagnetic compatibility; radio wave propagation; transmission loss

Haines, R. H., and S. E. Litts (1989), The SUM land mobile model: application of the spectrum use measure to the land mobile service, NTIA Report 89-248, September, 40 pp. (NTIS Order No. PB 90-130204/AS)

The Spectrum Use Measure (SUM) technique quantifies and graphically depicts the amount of spectrum resources used in a region within a frequency band. The SUM technique was originally developed to calculate spectrum use for a fixed system. This report describes the extension of the SUM model to calculate spectrum use for land mobile systems and the application of the land mobile model to the 406.1- to 420-MHz frequency band. An enhancement to the model that greatly reduces the run time is also discussed. The report concludes that the SUM concepts are applicable to land mobile systems and recommends extension of the model to additional services and frequency bands.

Key words: fixed service; interference; land mobile service; spectrum resources; Spectrum Use Measure (SUM); Spectrum Use Bandwidth (SUB); Spectrum-Area Use Product (SAUP); Spectrum-Area Use Index (SAUI); Spectrum Use Factor (SUF); Spectrum Use Index (SUI); SUM land mobile model

Hinkle, R. L., and A. Farrar (1989), Spectrum-conservation techniques for fixed microwave systems, NTIA Report 89-243, May, 55 pp. (NTIS Order No. PB 89-207609/AS)

Since the spectrum is a limited natural resource, the spectrum management community has a major interest in identifying spectrum conservation techniques that will provide more efficient spectrum utilization. Advances in new technology for fixed microwave systems in antennas, modulation schemes, and signal processing techniques offer increased efficiency in spectrum utilization. This report analyzes the spectrum-conserving properties of the various new technologies for fixed microwave systems applying the concepts in CCIR Report 662-2 and was defined as the spectrum conservation factor (SCF). The report concludes that the SCF technique is an effective indicator of the spectrum-conserving properties of technologies that can be used to develop new spectrum standards.

Key words: fixed microwave system; 7125-8500-MHz band; spectrum conservation factor (SCF), spectrum efficiency

Hoffmeyer, J. A., and T. J. Riley (1989), Digital European Backbone performance: A 12-month summary for the Frankfurt north segment, NTIA Report 89-247, August, 42 pp. (NTIS Order No. PB 90-118464/AS)

This report describes the interim results of an 18-month digital microwave transmission network performance and propagation measurement project that was conducted on a portion of the Defense Communications System in West Germany. Only the first 12 months of data are summarized in this report. More than 3 gigabytes of data were collected between April 1988 and March 1989. The report provides the results of bit-error-rate measurements made at the 56 kb/s user level on one long (99 km) line-of-sight (LOS) link and at the 64 kb/s user level on two end-to-end channels consisting of multiple LOS and/or troposcatter radio links. The report also provides summaries of 12 months of received-signal-level measurements on five LOS links and one troposcatter link.

Key words: DEB; digital radio performance; DRAMA; LOS propagation; military standard (MIL-STD); multipath fading; propagation measurements; radio outages; transmission system performance standards; troposcatter

Hufford, G. A., and H. J. Liebe (1989), Millimeter-wave propagation in the mesosphere, NTIA Report 89-249, September, 62 pp. (NTIS Order No. PB 90-119868/AS)

At heights between 30 and 100 km above Earth, the oxygen absorption lines near 60 GHz together with the geomagnetic field cause the atmosphere to become an anisotropic medium. This report discusses why this is so and how to compute the consequent effects. It describes the computer program ZEEMAN, which allows the user to display in either graphical or tabular form many aspects of how radio waves propagate through this medium.

Key words: anisotropic media; mesosphere; millimeter waves; oxygen absorption lines; polarization; radio propagation; Zeeman effect

Sowers, M. W., G. R. Hand, and C. M. Rush (1989), Monitoring of harmful interference to the HF broadcast service: IV. Results of the July 1988 coordinated monitoring period, NTIA Report 89-244, June, 114 pp. (NTIS Order No. PB 89-231732/AS)

This is the fourth in a series of reports describing the results of studies to determine the location of sources of harmful

interference to the high frequency broadcasting service. Using observations recorded during the July 1988 monitoring program conducted under the auspices of the International Frequency Registration Board and observations from monitoring stations coordinated by the Institute for Telecommunication Sciences, the report identifies frequently observed emitters of harmful interference and their locations and notes the extent of such interference with programs of leading international broadcast organizations.

Key words: direction finding; harmful interference; HF broadcasting; HF jamming; HF propagation

Violette, E., R. Espeland, and K. C. Allen (1988), Millimeter-wave propagation characteristics and channel performance for urban-suburban environments, NTIA Report 88-239, December, 178 pp. (NTIS Order No. PB 89-180251/AS)

Measurements were performed in an urban-suburban environment with narrowband and wideband rf probes, which include millimeter-wave frequencies, in order to study propagation characteristics for street-level paths. The primary objective of this report is to evaluate the performance of the rf channels in these environments for both line-of-sight and non-line-of-sight paths and to compare a model developed for line-of-sight paths to measurements taken in Denver, CO.

Key words: millimeter wave; model; performance; propagation; urban-suburban

Vogler, L. E., and J. A. Hoffmeyer (1988), A new approach to HF channel modeling and simulation, Part I: Deterministic model, NTIA Report 88-240, December, 44 pp. (NTIS Order No. PB 89-203962/AS)

This report describes a new and unique approach for modeling either narrowband or wideband high frequency (HF) channels. Although narrowband models of the HF channel have existed for many years, they are applicable to only a limited set of actual propagation conditions. The need for an HF channel model that is valid for both narrow and wide bandwidths over a more extensive range of propagation conditions provided the motivation for the research documented in this report. The report also describes the development of a channel transfer function for the HF channel that accurately models a wide variety of propagation conditions and can be used for the evaluation of wideband HF systems. The first part of this modeling effort has been to develop a model that represents the median channel conditions. Good agreement has been found between the model and wideband propagation measurements taken

during relatively stable conditions. The report provides comparisons between ionograms generated by the model and measured wideband ionograms that have been reported in the literature. Encouraging results have also been found in comparing model outputs with measured time-history plots.

Key words: channel transfer function; HF channel models; HF propagation; over-the-horizon radar (OTHR); spread-spectrum; wideband communications; widerand HF

Special Publications

National Telecommunications and Information Administration
(1989), Long range plan for management and use of the
radio spectrum by agencies and establishments of the
Federal Government, NTIA Special Publication 89-22,
June, 156 pp. (NTIS Order No. PB 89-232367/AS)

This document sets forth a plan for more effective management of the radio frequency spectrum and encourages the efficient use of spectrum-related technologies and applications. It delineates plans for spectrum-related telecommunications use by the Federal Government. It is a dynamic plan reflecting U.S. interest in efficient, cost-effective spectrum management and use, and in minimizing rules and regulations. This Long Range Plan will be updated biannually and supplemented as appropriate in cooperation with the Federal Communications Commission.

★ U.S. GOVERNMENT PRINTING OFFICE: 1989-773-002/11008

NTIA FORMAL PUBLICATION SERIES

NTIA MONOGRAPH

A scholarly, professionally oriented publication dealing with state-of-the-art research or an authoritative treatment of a broad area. A monograph is expected to have a long lifespan.

NTIA SPECIAL PUBLICATION

Information derived from or of value to NTIA activities such as conference proceedings, bibliographies, selected speeches, course and instructional materials, and directories.

NTIA HANDBOOK

Information pertaining to technical procedures; reference and data guides, and formal user's manuals that are expected to be pertinent for a long time.

NTIA REPORT

Important contributions to existing knowledge but of less breadth than a monograph, such as results of completed projects and major activities, specific major accomplishments, or NTIA-coordinated activities.

NTIA RESTRICTED REPORT

Contributions that fit the NTIA Report classification but that are limited in distribution because of national security classification or Departmental constraints. This material receives full review and quality control equivalent to the open-literature report series.

NTIA CONTRACTOR REPORT

Information generated under an NTIA contract or grant and considered an important contribution to existing knowledge.

SPONSOR-ISSUED REPORTS

NTIA authors occasionally produce reports issued under an other-agency sponsor's cover. These reports generally embody the criteria of the NTIA Report series.

For information about NTIA publications, contact the Executive Office at 325 Broadway, Boulder, Colorado 80303 (telephone: 303-497-3572).

This report is for sale by the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.